S 06-009
ER 06-09-007.

Storm Water Management Plan
For Priority Projects
(Major SWMP)

Project Name:	Sunrise Villas
Permit Number (Land Development Projects):	
Work Authorization Number (CIP):	
Applicant:	Bruce Steingraber
Applicant's Address:	24665 Rancho Santa Teresa, Ramona, Ca 92065
Plan Prepare By (Leave blank if same as applicant):	Partners Planning & Engineering 15938 Bernardo Center Dr. San Diego, CA 92127
Date:	August 23, 2006
Revision Date (If applicable):	April 11, 2007

The County of San Diego Watershed Protection, Storm Water Management, and Discharge Control Ordinance (WPO) (Ordinance No. 9424) requires all applications for a permit or approval associated with a Land Disturbance Activity must be accompanied by a Storm Water Management Plan (SWMP) (section 67.804.f). The purpose of the SWMP is to describe how the project will minimize the short and long-term impacts of receiving water quality. Projects that meet the criteria for a priority project are required to prepare a Major SWMP.

Since the SWMP is a living document, revisions may be necessary during various stages of approval by the County. Please provide the approval information requested below.

Project Review Stage	Does the SWMP need revisions?		If YES, Provide Revision Date
	YES	NO	

Instructions for a Major SWMP can be downloaded at http://www.co.san-diego.ca.us/dpw/stormwater/susmp.html.

Completion of the following checklist and attachments will fulfill the requirements of a Major SWMP for the project listed above.

PROJECT DESCRIPTION

Please provide a brief description of the project in the following box. For example:
The 50-acre RC Ranch project is located on the south side of San Miguel Road in the County of San Diego (See Attachment 1). The project is approximately 1.0 mile east of the intersection of San Miguel Avenue and San Miguel Road and 1 mile south of the Sweetwater Reservoir. This project will consist of a planned residential community comprising of 45 single-family homes 72 and multi-unit dwellings.''

The project site currently remains in its natural condition. The project includes the construction of a Multi-family residential pad and necessary storm water facilities. The project lies south of State Route 67 and east of Letton Rd. The project will be accessed off Kelly Avenue. See attachment 'A' for Location Map.

PRIORITY PROJECT DETERMINATION

Please check the box that best describes the project. Does the project meet one of the following criteria?

PRIORITY PROJECT	YES	NO
Redevelopment within the County Urban Area that creates or adds at least 5,000 net square feet of additional impervious surface area	X	
Residential development of more than 10 units		X
Commercial developments with a land area for development of greater than 100,000 square feet		X
Automotive repair shops		X
Restaurants, where the land area for development is greater than 5,000 square feet		X
Hillside development, in an area with known erosive soil conditions, where there will be grading on any natural slope that is twenty-five percent or greater, if the development creates 5,000 square feet or more of impervious surface		X
Environmentally Sensitive Areas: All development and redevelopment located within or directly adjacent to or discharging directly to an environmentally sensitive area (where discharges from the development or redevelopment will enter receiving waters within the environmentally sensitive area), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition.		X
Parking Lots 5,000 square feet or more or with 15 parking spaces or more and potentially exposed to urban runoff	X	
Street, roads, highways, and freeways which would create a new paved surface that is 5,000 square feet or greater		X

Limited Exclusion: Trenching and resurfacing work associated with utility projects are not considered priority projects. Parking lots, buildings and other structures associated with utility projects are subject to SUSMP requirements if one or more of the criteria above are met.

If you answered NO to all the questions, then STOP. Please complete a Minor SWMP for your project.

If you answered YES to any of the questions, please continue.

The following questions provide a guide to collecting information relevant to project stormwater quality issues. Please provide a description of the findings in text box below.

	QUESTIONS	COMPLETED	N/A
1.	Describe the topography of the project area and adjacent area.	X	
2.	Describe the local land use within the project area and adjacent areas.	X	
3.	Evaluate the presence of dry weather flow.		X
4.	Determine the receiving waters that may be affected by project throughout the project life cycle (i.e., construction, maintenance and operation).	X	
5.	For the project limits, list the 303 (d) impaired receiving water bodies and their constituents of concern.	X	
6.	Determine if there are any High Risk Areas (municipal or domestic water supply reservoirs or groundwater percolation facilities). Within the project limits.		X
7.	Determine the Regional Board special requirements, including TMDLs, effluent limits, etc.	X	
8.	Determine the general climate of the project area. Identify annual rainfall and rainfall intensity curves.	X	
9.	If considering Treatment BMP's, determine the soil classification, permeability, erodibility, and depth to groundwater.	X	
10.	Determine contaminated or hazardous soils within the project area.	X	

Please provide a description of the findings in the following box. For example:
The project is located in the San Diego Hydrologic unit. The area is characterized by rolling grassy hills and shrubs. Runoff from the project drains into a MS4 that eventually drains to Los Coches Creek. Within the project limit there are no 303 (d) impaired receiving water and no Regional Board special requirements.

The project site consists of gentle slopes with approximately 100% of the property under 5% in slope gradient. The project site has an elevation range from approximately 1654.5 feet to 1650 feet MSL. The project site is bounded by single family residences to the east, west and south, and Kelly Avenue to the north. The site is currently vacant. This project site is located within the Ramona Hydrologic Subarea (HSA 905.41) of the Santa Maria Valley Hydrologic Area of the San Dieguito Hydrologic Unit. The project area is currently a vacant site on a .82 acre lot. The

site accepts off-site run-on from adjacent properties to the east. The majority of the runoff generated on-site, as well as the off-site run-on, sheet flows to the existing natural drainage channel located adjacent to the westerly property line of the project site. The runoff is then conveyed within the limits of the channel to the southwest towards Santa Maria Creek. The proposed project will not significantly alter drainage patterns on-site. Runoff from the site will be directed through grass-lined swales for storm water quality prior to exiting the site and onto the proposed paved public road located adjacent to the northerly boundary. Overall, the project area represents 0.002 percent of the watershed (0.82 acres versus 40,661 acres). There is no dry weather flow over the site. There are no Regional Board special requirements for the site. No contaminated or hazardous soils exist within the project area.

Complete the checklist below to determine if Treatment Best Management Practices (BMPs) are required for the project.

No.	CRITERIA	YES	NO	INFORMATION
1.	Is this an emergency project		X	If YES, go to 6. If NO, go to 2.
2.	Have TMDLs been established For surface waters within the project limit?		X	If YES, go to 5. If NO, continue to 3.
3.	Will the project directly discharge to a 303 (d) impaired receiving water body?		X	If YES, go to 5. If NO, go to 4.
4.	Is the project within the urban and environmentally sensitive areas as defined on the maps in Appendix B of the County of San Diego Standard Urban Storm Water Mitigation Plan for Land Development and Public Improvement Projects?		X	If YES, continue to 5. If No, go to 6.
5.	Consider approved Treatment BMPs for the project.			If YES, to to 7.
6.	Project is not required to consider Treatment BMPs			Document for Project Files by referencing this checklist.
7.	End			

Now that the need for a treatment BMPs has been determined, other information is needed to complete the SWMP.

WATERSHED

Please check the watershed(s) for the project.

□ San Juan	□ Santa Margarita	□ San Luis Rey	□ Carlsbad
X San Dieguito	□ Penasquitos	□ San Diego	□ Pueblo San Diego
□ Sweetwater	□ Otay	□ Tijuana	

Please provide the hydrologic sub-area and number(s)

Number	Name
905.41	Ramona Hydrologic Subarea

Please provide the beneficial uses for Inland Surface Waters Ground Waters. Beneficial Uses can be obtained from the Water Quality Control Plan For The San Diego Basin, which is available at the Regional board office or at http:/www.swrcb.ca.gov/rwqcb9/programs/basinsplan.html.

Surface Waters	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRESH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Inland Surface Waters																
	905.41	X	X	X	X				X	X		X		X		
Ground Waters																
	905.41	X	X	X	X											

X Existing Beneficial Use
O Potential Beneficial Use
* Excepted from Municipal

POLLUTANTS OF CONCERN

Using Table 1, identify pollutants that are anticipated to be generated from the proposed priority project categories. Pollutants associated with any hazardous material sites that have been remediated or are not threatened by the proposed project are not considered a pollutant of concern.

	General Pollutant Catergories								
Priority Project Categories	Sediments	Nutrients	Heavy Metals	Organic Compounds	Trash& Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticid
Detached Residential Development	X	X			X	X	X	X	X

Attached Residential Development	X	X			X	p(1)	p(2)	P	X
Commercial Development >100,000ft^2	p(1)	p(1)				p(5)		p(3)	p(5)
Automotive Repair Shops			X	X(4)(5)	X		X		
	Sediments	Nutrients	Heavy Metals	Organic compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticide
Restaurants					X	X	X	X	
Hillside Development >5,000 ft^2	X	X			X	X	X		X
Parking Lots	p(1)	p(1)	X		X	p(1)	X		p(1)
Streets, Highways & Freeways	X	p(1)	X	X(4)	X	p(5)	X		

X = anticipated
P = potential
(1) A potential pollutant if landscaping exists on-site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

Note: If other monitoring data that is relevant to the project is available. Please include as Attachment C.

CONSTRUCTION BMPs

Please check the construction BMPs that may be used. The BMPs selected are those that will be implemented during construction of the project. The applicant is responsible for the placement and maintenance of the BMPs selected.

A detailed description of the construction BMPs will be developed during the Grading Plan and Improvement Plan Engineering. Since the project is in the preliminary development phase only a listing of potential types of temporary BMPs are available. This includes the following:

X Silt Fence
X Fiber Rolls
X Street Sweeping and Vacuuming
X Storm Drain Inlet Protection
X Stockpile Management
X Solid Waste Management
X Stabilized Construction Entrance/Exit
X Desilting Basin
X Gravel Bag Berm
X Sandbag Barrier
X Material Delivery and Storage
X Spill Prevention and Control
X Concrete Waste Management
X Water Conservation Practices

X Dewatering Operations X Paving and Grinding Operations
X Vehicle and Equipment Maintenance
X Any minor slopes created incidental to construction and not subject to a minor grading permit shall be protected by covering with plastic tarp prior to a rain event, and shall have vegetative cover reestablished within 180 days of completion of the slope and prior to final building approval.

SITE DESIGN

To minimize stormwater impacts, site design measures must be addressed. The following checklist provides options for avoiding or reducing potential impacts during project planning. If YES is checked, it is assumed that the measure was used for this project. If NO is checked, please provide a brief explanation why the option was not selected in the text box below.

	OPTIONS		YES	NO	N/A
1.	Can the project be relocated or realigned to avoid/reduce impacts to receiving waters or to increase the preservation of critical (or problematic) areas such as floodplains, steep slopes, wetlands, and areas with erosive or unstable soil conditions?			X	
2.	Can the project be designed to minimize impervious footprint?		X		
3.	Conserve natural areas where fesible?			X	
4.	Where landscape is proposed, can rooftops, impervious sidewalks, walkways, trails and patios be drained into adjacent landscaping?		X		
5.	For roadway projects, can structures and bridges be designed or located to reduce work in live streams and minimize construction impacts?				X
6.	Can any of the following methods be utilized to minimize erosion from slopes:				
	6.a.	Disturbing existing slopes only when necessary?	X		
	6.b.	Minimize cut and fill areas to reduce slope lengths?	X		
	6.c.	Incorporating retaining walls to reduce steepness of slopes or to shorten slopes?			X
	6.d.	Providing benches or terraces on high cut and fill slopes to reduce concentration of flows?			X
	6.e.	Rounding and shaping of slopes to reduce concentrated flow?			X
	6.f.	Collecting concentrated flows in stabilized drains and channels?	X		

Please provide a brief explanation for each option that was checked N/A or NO in the following box.

Cannot relocate or realign the project due to site restrictions. Entire site will be developed. No work will be done in live streams. No retaining walls on site. No high cut or fill slopes on site. Site is relatively flat, no slopes exist.

If the project includes work in channels, then complete the following checklist. Information shall be obtained from the project drainage report.

	CRITERIA	YES	NO	N/A	COMMENTS
1.	Will the project increase velocity or volume of downstream flow?			X	If YES, go to 5.
2.	Will the project discharge to unlined channels?			X	If YES, go to 5.
3.	Will the project increase potential sediment load of downstream flow?			X	If YES, go to 5.
4.	Will the project encroach, cross, realign, or cause other hydraulic changes to a stream that may affect upstream and/or downstream channel stability?			X	If YES, go to 7.
5.	Review channel lining materials and design for stream bank erosion.			X	Continue to 6.
6.	Consider channel erosion control measures within the project limits as well as downstream. Consider scour velocity.			X	Continue to 7.
7.	Include, where appropriate, energy dissipation devices at culverts.			X	Continue to 8.
8.	Ensure all transitions between culvert outlets/headwalls/wingwalls and channels are smooth to reduce turbulence and scour.			X	Continue to 9.
9.	Include, if appropriate, detention facilities to reduce peak discharges.			X	
10.	"Hardening" natural downstream areas to prevent erosion is not an acceptable technique for protecting channel slopes, unless pre-development conditions are determined to be so erosive that hardening would be required even in the absence of the proposed development.			X	Continue to 11.
11.	Provide other design principles that are comparable and equally effective.			X	Continue to 12.
12.	End			X	

SOURCE CONTROL

Please complete the following checklist for source Control BMps. If the BMP is not applicable for this project, then check N/A only at the main category.

BMP			YES	NO	N/A
1.	**Provide Storm Drain System Stenciling and Signage**				
	1.a.	All storm drain inlets and catch basins within the project area shall have a stencil or tile placed with prohibitive language (such as: "NO DUMPING- DRAINS TO _____") and/or graphical icons to discourage illegal dumping.			X
	1.b.	Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the project area.			X
2.	**Design Outdoors Material Storage Areas to Reduce Pollution Introduction**				
	2.a.	This is a detached single-family residential project. Therefore, personal storage areas are exempt from this requirement.			X
	2.b.	Hazardous materials with the potential to contaminate urban runoff shall either be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the storm water conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.	X		
	2.c.	The storage area shall be paved and sufficiently impervious to contain leaks and spills.	X		
	2.d.	The storage area shall have a roof or awning to minimize direct precipitation within the secondary containment area.	X		
3.	**Design Trash Storage Areas to Reduce Pollution Introduction**				
	3.a.	Paved with an impervious surface, designed not to allow run-on from adjoining areas, screened or walled to prevent off-site transport of trash; or,	X		
	3.b.	Provide attached lids on all trash containers that exclude rain, or roof or awning to minimize direct precipitation.	X		
4.	**Use Efficient Irrigation Systems & Landscape Design**				
	The following methods to reduce excessive irrigation runoff shall be considered, and incorporated and implemented where determined applicable and feasible.				
	4.a.	Employing rain shutoff devices to prevent irrigation after precipitation.	X		
	4.b.	Designing irrigation systems to each landscape area's specific water requirements.	X		
	4.c.	Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.	X		
	4.d.	Employing other comparable, equally effective, methods to reduce irrigation water runoff.	X		
5.	**Private Roads**				
	The design of private roadway drainage shall use at least one of the following		X		

	5.a.	Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings.		X	
		BMP	**YES**	**NO**	**N/A**
	5.b.	Urban curb/swale system: street slopes to curb, periodic swale inlets drain to vegetated swale/biofilter.		X	
	5.c.	Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to storm water conveyance system.		X	
	5.d.	Other methods that are comparable and equally effective within the project.		X	
6.	**Residential Driveways & Guest Parking**				
	The design of driveways and private residential parking areas shall use one at least of the following features.				
	6.a.	Design driveways with shared access, flared (single lane at street) or wheelstrips (paving only under tires); or, drain into landscaping prior to discharging to the storm water conveyance system.	X		
	6.b.	Uncovered temporary or guest parking on private residential lots may be: paved with a permeable surface; or, designed to drain into landscaping prior to discharging to the storm water conveyance system.	X		
	6.c.	Other features which are comparable and equally effective.		X	
7.	**Dock Areas**				
	Loading/unloading dock areas shall include the following.				
	7.a.	Cover loading dock areas, or design drainage to preclude urban run-on and runoff.			X
	7.b.	Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.			X
	7.c.	Other features which are comparable and equally effective.			X
8.	**Maintenance Bays**				
	8.a.	Repair/ maintenance bays shall be indoors; or, designed to preclude urban run-on and runoff.			X
	8.b.	Design a repair/maintenance bay drainage system to capture all wash water, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.			X
	8.c.	Other features which are comparable and equally effective.			X
9.	**Vehicle Wash Areas**				
	Priority projects that include areas for washing/steam cleaning of vehicles shall use the following.				X
	9.a.	Self-contained; or covered with a roof or overhang.			X
	9.b.	Equipped with a clarifier or other pretreatment facility.			X
	9.c.	Properly connected to a sanitary sewer.			X
	9.d.	Other features which are comparable and equally effective.			X
10.	**Outdoor Processing Areas**				
	Outdoor process equipment operations, such as rock grinding or crushing, painting or coating, grinding or shading , degreasing or parts cleaning, waste piles, and wastewater and solid waste treatment and disposal, and other operations determined to be a potential threat to water quality by the County shall adhere to the following requirements.				

	10.a.	Cover or enclose areas that would be the most significant source of pollutants; or, slope that area toward a dead-end sump; or, discharge to the sanitary sewer system following appropriate treatment in accordance with conditions established by the applicable sewer agency.			X
	10.b.	Grade or berm area to prevent run-on from surrounding areas.			X
	10.c.	Installation of storm drains in areas of equipment repair is prohibited.			X
	10.d.	Other features which are comparable or equally effective.			X
11.	**Equipment Wash Areas**				
	Outdoor equipment/accessory washing and stream cleaning activities shall be.				
	11.a.	Be self-contained; or, covered with a roof or overhang.			X
	11.b.	Be equipped with a clarifier, grease trap or other pretreatment facility, as appropriate			X
	11.c.	Be properly connected to a sanitary sewer.			X
	11.d.	Other features which are comparable or equally effective.			X
12.	**Parking Areas**				
	The following design concepts shall be considered, and incorporated and implemented where determined applicable and feasible by the County.				
	12.a.	Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.	X		
	12.b.	Overflow parking (parking stalls provided in excess of the County's minimum parking requirements) may be constructed with permeable paving.	X		
	12.c.	Other design concepts that are comparable and equally effective.		X	
13.	**Fueling-Area**				
	Non-retail fuel dispensing areas shall contain the following.				
	13.a.	Overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area shall drain to the project's treatment control BMP(s) prior to discharging to the storm water conveyance system.			X
	13.b.	Paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete shall be prohibited.			X
	13.c.	Have an appropriate slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of urban runoff.			X
	13.d.	At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.			X

Please list other project specific source Control BMPs in the following box. Write **N/A** if there are none and briefly explain.

Routine maintenance and good housekeeping will be used to keep the site clean and free of foreign debris that can impact storm water. The site trash and recycling receptacle areas are to be kept free of debris. Trash and recyclable materials are to be removed from the site weekly and are the responsibility of the owner Frank Santa. The owner agrees to inspect and maintain or execute a contract for the inspection and maintenance of the subject area in order to prevent the possible presence of harmful or hazardous materials. The inspection of the trash and recycling area shall be done on a Bi-weekly basis and maintenance will be conducted on an as needed basis.

ON-SITE TREATMENT CONTROL

TO select a structural treatment BMP using Treatment Control BMP Selection Matrix (Table 2), each priority project shall compare the list of pollutants for which the downstream receiving waters are impaired (if any), with the pollutants anticipated to be generated by the project (as identified in Table 1). Any pollutants identified by Table 1, which are also causing a Clean Water Act section 303 (d) impairment of the receiving waters of the project, shall be considered primary pollutants of concern. Priority projects that are anticipated to generate a primary pollutant of concern shall select a single or combination of storm water BMPs from Table 2, which **maximizes pollutant removal** for the particular primary pollutant(s) of concern.

Priority projects that are **not** anticipated to generate a pollutant for which the receiving water is Clean Water Act Section 303 (d) impaired shall select a single or combination of storm water BMPs from Table 2, which are effective for pollutant removal of the identified secondary pollutants of concern, consistent with the "maximum extent practicable" standard.

Table 2. Treatment Control BMP Selection Matrix

Pollutant of Concern	Treatment Control BMP Categories						
	Bio-filters	Detention Basins	Infiltration Basins [2]	Wet Ponds or Wetlands	Drainage Inserts	Filtration	Hydrodynamic Separator Systems[3]
Sediment	**M**	H	H	H	L	H	M
Nutrients	**L**	M	M	M	L	M	L
Heavy Metals	**M**	M	M	H	L	H	L
Organic Compounds	**U**	U	U	M	L	M	L
Trash & Debris	**L**	H	U	H	M	H	M
Oxygen Demanding Substances	**L**	M	M	M	L	M	L

Bacteria	**U**	U	H	H	L	M	L
Oil & Grease	**M**	M	U	U	L	H	L
Pesticides	**U**	U	U	L	L	U	L

(1) Copermittes are encouraged to periodically assess the performance characteristics of many of these BMPs to update this table.
(2) Including trenches and porous pavement.
(3) Also known as hydrodynamic devices and baffle boxes.

L: Low removal efficiency:
M: Medium removal efficiency:
H: High removal efficiency:
U: Unknown removal efficiency
Sources: guidance Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993). National Stormwater Best Management Practices Database (2001), Guide for BMP Selection in Urban Developed Areas (2001). And Caltrans New Technology Report (2001).

A Treatment BMP must address runoff from developed areas. Please provide the post-construction water quality values for the project. Label outfalls on the BMP map. Q_{WQ} is dependent on the type of treatment BMP selected for the project.

Outfall	**Tributary Area (acres)**	**Q_{100} (cfs)**	**Q_{WQ} (cfs)**
Pre	1.49	2.3	0.12
Post	1.49	2.3	0.18

Please check the box(s) that best describes the Treatment BMP(s) selected for this project.

Biofilters
X Grass swale
□ Grass strip
□ Wetland vegetation swale
□ Bioretention

Detention Basins
X Extended/dry detention basin with grass lining.
□ Extended/dry detention basin with impervious lining.

Infiltration Basins
□ Infiltration basin
□ Infiltration trench
□ Porous asphalt
□ Porous concrete
X Porous modular concrete block

Wet Ponds or Wetlands
□ Wet pond/basin (permanent pool)
□ Constructed wetland

Drainage Inserts (See note below)

□ Oil/Water separator
□ Catch basin insert
□ Storm drain inserts
□ Catch basin screens

Filtration

□ Media filtration
□ Sand filtration

Hydrodynamic Separator systems

□ Swirl Concentrator
□ Cyclone Separator
□ Baffle Separator
□ Gross Solids Removal Device
□ Linear Radial Device

Note: Catch basin inserts and storm drain inserts are excluded from use on County maintained right-of-way and easements.

Include Treatment Datasheet as Attachment E. The datasheet should include the following:	**COMPLETED**	**NO**
1. Description of how treatment BMP was designed. Provide a description for each type of treatment BMP.	X	
2. Engineering calculations for the BMP(s)	X	

Please describe why the selected treatment BMP(s) was selected for this project. For projects utilizing a low performing BMP, please provide a detailed explanation and justification.

There is no existing storm drain. Grass swales and permeable modular concrete block were used due to low maintenance, their ability to clean better and their asthetics.

On-site Maintenance

Please check the box that best describes the maintenance mechanism(s) for this project.

CATEGORY	**SELECTED**	
	YES	**NO**
First		X
Second	X	
Third		X
Fourth		X

This project proposes the use of structural BMPs designated in the County of San Diego, SUSMP Chapter 5 and Section 2, as category 2 BMPs, i.e. Bio-filter (Grass-swales and pervious modular concrete block). The Owner/Developer shall assume responsibility for the maintenance of these BMPs. The developer shall record an easement with covenant in accordance with County Guideline category 2. This will serve in three ways (a) It will commit the land to being used only for purposes of the BMP: (b) It will include an agreement by the landowner, to maintain the facilities in accordance with the SMP (this obligation would be passed on to future purchasers or successors of the landowner, as a covenant): and (c) it would include an easement giving the county the right to enter onto the land (and any necessary adjacent land needed for access) to maintain the BMPs.

Please briefly describe the long-term fiscal resources for the selected maintenance mechanism(s).

Please briefly describe the long-term fiscal resources for the selected maintenance mechanism(s).

Frank Santa is aware of his responsibility to maintain all construction and post-construction BMPs to ensure they are all in good working order. He understands that as part of the grading permit application package, the County will require him to sign a Storm Water Management Plan document identifying owner responsibility for BMP maintenance, repair and replacement until the County of San Diego accepts an alternative mechanism to ensure such maintenance, repair and replacement. He also understands that the County of San Diego will require the above described BMP easement/covenant to be signed and recorded on or prior to the recordation of the Final or Parcel map. The estimated Operation and Maintenance costs for a two-year period are approximately $5,944. Frank Santa agrees to provide this amount as security to substantiate the maintenance agreement; this agreement would remain in place as an interim for a period of five years. The security amount shall be provided in the form of a letter of credit, cash deposit, or other form acceptable to the County. See attached cost breakdown for maintenance on a vegetated swale as downloaded from the County website.

OFF-SITE TREATMENT CONTROL

TO select a structural treatment BMP using Treatment Control BMP Selection Matrix (Table 2), each priority project shall compare the list of pollutants for which the downstream receiving waters are impaired (if any), with the pollutants anticipated to be generated by the project (as identified in Table 1). Any pollutants identified by Table 1, which are also causing a Clean Water Act section 303 (d) impairment of the receiving waters of the project, shall be considered primary pollutants of concern. Priority projects that are anticipated to generate a primary pollutant of concern shall select a single or combination of storm water BMPs from Table 2, which **maximizes pollutant removal** for the particular primary pollutant(s) of concern.

Priority projects that are **not** anticipated to generate a pollutant for which the receiving water is Clean Water Act Section 303 (d) impaired shall select a single or combination of storm water BMPs from Table 2, which are effective for pollutant removal of the identified secondary pollutants of concern, consistent with the "maximum extent practicable" standard.

Table 2. Treatment Control BMP Selection Matrix

Pollutant of Concern	Treatment Control BMP Categories						
	Bio-filters	Detention Basins	Infiltration Basins [2]	Wet Ponds or Wetlands	Drainage Inserts	Filtration	Hydrodynamic Separator Systems[3]
Sediment	**M**	H	H	H	L	H	M
Nutrients	**L**	M	M	M	L	M	L
Heavy Metals	**M**	M	M	H	L	H	L
Organic Compounds	**U**	U	U	M	L	M	L
Trash & Debris	**L**	H	U	H	M	H	M
Oxygen Demanding Substances	**L**	M	M	M	L	M	L
Bacteria	**U**	U	H	H	L	M	L
Oil & Grease	**M**	M	U	U	L	H	L
Pesticides	**U**	U	U	L	L	U	L

(1) Copermittes are encouraged to periodically assess the performance characteristics of many of these BMPs to update this table.
(2) Including trenches and porous pavement.
(3) Also known as hydrodynamic devices and baffle boxes.

L: Low removal efficiency:
M: Medium removal efficiency:
H: High removal efficiency:
U: Unknown removal efficiency
Sources: guidance Specify Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993). National Stormwater Best Management Practices Database (2001), Guide for BMP Selection in Urban Developed Areas (2001). And Caltrans New Technology Report (2001).

A Treatment BMP must address runoff from developed areas. Please provide the post-construction water quality values for the project. Label outfalls on the BMP map. Q_{WQ} is dependent on the type of treatment BMP selected for the project.

Outfall	**Tributary Area (acres)**	**Q_{100} (cfs)**	**Q_{WQ} (cfs)**
Pre	0.37	0.8	0.07
Post	0.37	0.8	0.07

Please check the box(s) that best describes the Treatment BMP(s) selected for this project.

Biofilters

X Grass swale
□ Grass strip
□ Wetland vegetation swale
□ Bioretention

Detention Basins

□ Extended/dry detention basin with grass lining.
□ Extended/dry detention basin with impervious lining.

Infiltration Basins

□ Infiltration basin
□ Infiltration trench
□ Porous asphalt
□ Porous concrete
□ Porous modular concrete block

Wet Ponds or Wetlands

□ Wet pond/basin (permanent pool)
□ Constructed wetland

Drainage Inserts (See note below)

□ Oil/Water separator
□ Catch basin insert
□ Storm drain inserts
□ Catch basin screens

Filtration

□ Media filtration
□ Sand filtration

Hydrodynamic Separator systems

□ Swirl Concentrator
□ Cyclone Separator
□ Baffle Separator
□ Gross Solids Removal Device
□ Linear Radial Device

Note: Catch basin inserts and storm drain inserts are excluded from use on County maintained right-of-way and easements.

Please describe why the selected treatment BMP(s) was selected for this project. For projects utilizing a low performing BMP, please provide a detailed explanation and justification.

There is no existing storm drain in the immediate or general area. The existing Earthen/Grass swale will be utilized as the BMP. This BMP is located within the public right of way.

Off-site Maintenance

Please check the box that best describes the maintenance mechanism(s) for this project.

CATEGORY	SELECTED	
	YES	NO
First		X
Second		X
Third		X
Fourth	X	

This project proposes the use of an offsite structural BMPs designated in the County of San Diego, SUSMP Chapter 5 and Section 2, as category 4 BMPs, i.e. Bio-filter (Grass-swales). This BMP has been proposed by the County of San Diego as a means of servicing the public need and extending beyond the individual scope of the proposed development project. The County shall assume responsibility for the maintenance of this BMP. The proposed BMP currently exists today as earthen swale and is located in the natural drainage path. The proposed BMP is located within the county right of way and thus will not need a dedication.

Please briefly describe the long-term fiscal resources for the selected maintenance mechanism(s).

It shall be the responsibility of the County of San Diego to maintain, repair and replace the proposed off-site BMPs. The County shall assume responsibility of these BMPs until it accepts an alternative mechanism to ensure such maintenance, repair and replacement. The estimated Operation and Maintenance costs for a two-year period are approximately $5,944.

ATTACHMENTS

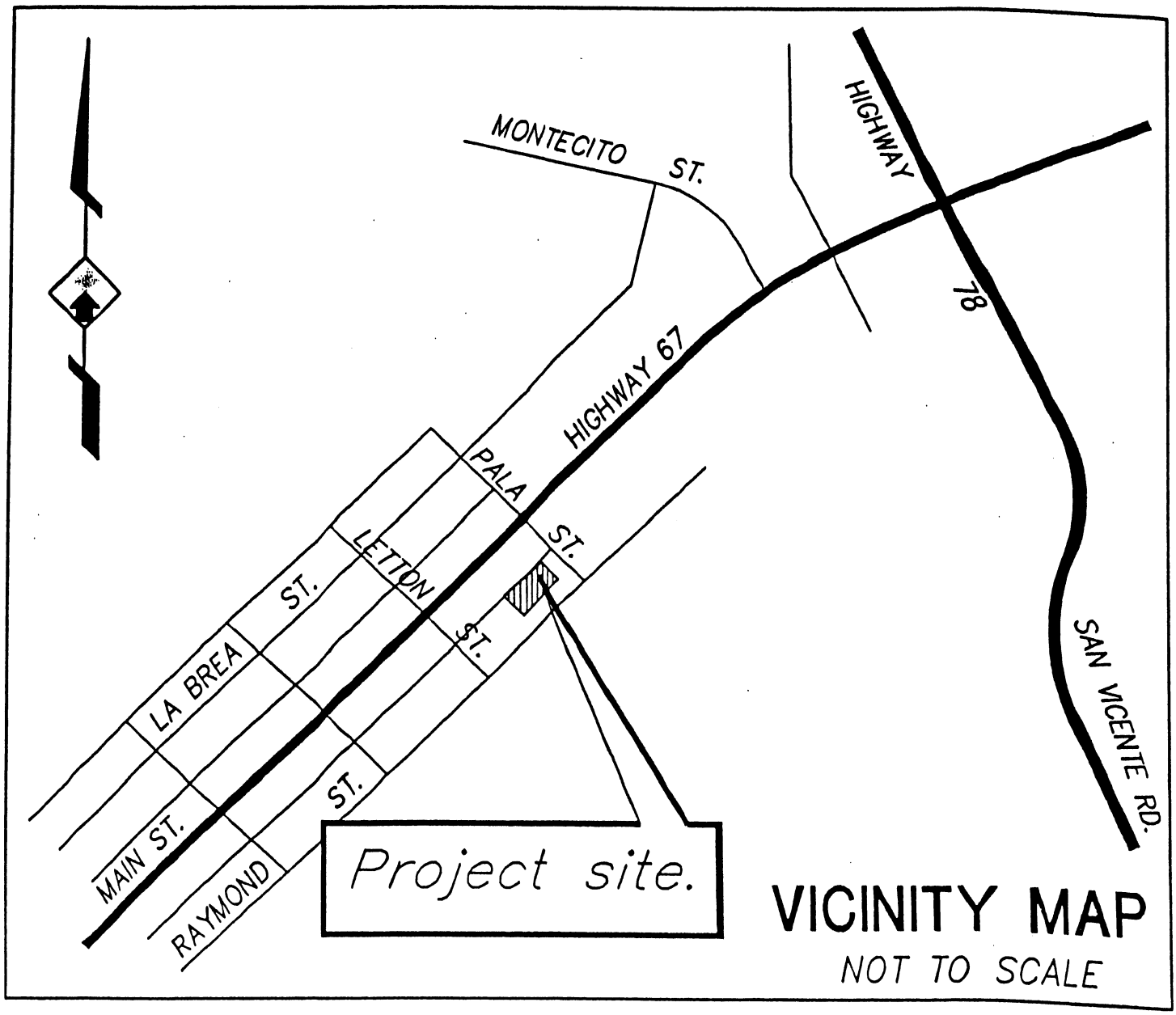
Please include the following attachments.

	ATTACHMENTS	COMPLETED	N/A
A	Project Location Map	X	
B	Site Map	X	
C	Relevant Monitoring Data		X
D	Treatment BMP Location Map	X	
E	Treatment BMP Datasheets	X	
F	Operation and Maintenance Program for Treatment BMPs	X	
G	Engineer's Certification Sheet	X	

Note: Attachments A and B may be combined.

ATTACHMENT A

LOCATION MAP



VICINITY MAP

NOT TO SCALE

ATTACHMENT B

PROJECT SITE MAP

ATTACHMENT C

RELEVANT MONITORING DATA

(**NOTE:** PROVIDE RELEVANT WATER QUALITY MONITORING DATA IF AVAILABLE.)

ATTACHMENT D

TREATMENT BMP LOCATION MAP

ATTACHMENT E

TREATMENT BMP DATASHEET

(**NOTE:** POSSIBLE SOURCE FOR DATASHEETS CAN BE FOUND AT WWW.CABMPHANDBOOKS.COM. INCLUDE ENGINEERING CALCULATIONS FOR SIZING THE TREATMENT BMP.)

Vegetated Swale TC-30

Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data							
	Removal Efficiencies (% Removal)						
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately $0.25 per ft². This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately $0.50 per ft², which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Seed, and Mulch[f]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Sod[g]								
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right) \times$ swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	$0.85 / 1,000 ft²/ mowing	$0.14 / linear foot	$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	$9.00 / 1,000 ft²/ year	$0.18 / linear foot	$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	$0.10 / linear foot / year	$0.10 / linear foot	$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	$0.30 / yd²	$0.01 / linear foot	$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	$0.15 / linear foot / year, plus $25 / inspection	$0.15 / linear foot	$0.15 / linear foot	Inspect four times per year
Total	--	$0.58 / linear foot	$ 0.75 / linear foot	--

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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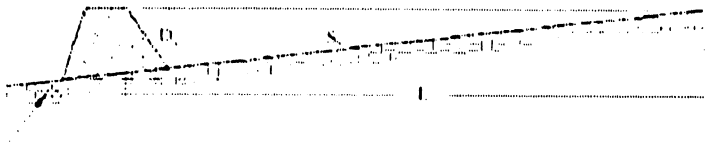
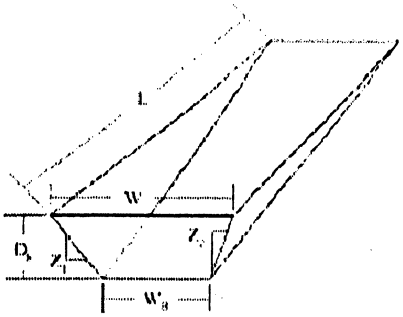


Provide for scour protection.

(a) Cross section of swale with check dam.

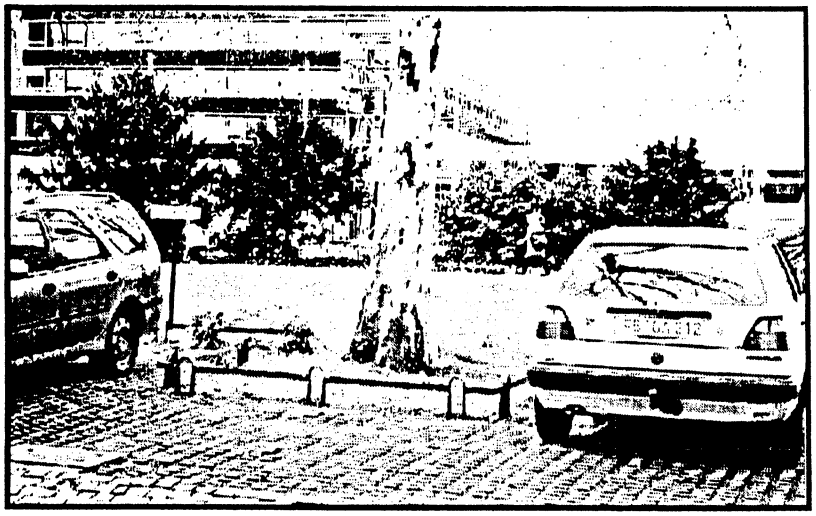


(b) Dimensional view of swale impoundment area.

Notation:

L = Length of swale impoundment area per check dam (ft)
D_s = Depth of check dam (ft)
S_s = Bottom slope of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Pervious Pavements SD-20



Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.
- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.
- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.
- The use of permeable pavement is restricted to gentle slopes.
- Porous block paving has a higher risk of abrasion and damage than solid blocks.

Design Considerations

Designing New Installations

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

Design Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.
- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.
- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.
- Water is present within the construction and can soften and weaken materials, and this must be allowed for.
- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.
- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.
- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.
- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

Construction/Inspection Considerations

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level
- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

Maintenance Requirements

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

Table 1 Typical Recommended Maintenance Regimes	
Activity	**Schedule**
■ Minimize use of salt or grit for de-icing ■ Keep landscaped areas well maintained ■ Prevent soil being washed onto pavement	Ongoing
■ Vacuum clean surface using commercially available sweeping machines at the following times: - End of winter (April) - Mid-summer (July / August) - After Autumn leaf-fall (November)	2/3 x per year
■ Inspect outlets	Annual
■ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required. ■ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage. ■ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement. ■ Sub-surface layers may need cleaning and replacing. ■ Removed silts may need to be disposed of as controlled waste.	As needed (infrequent) Maximum 15-20 years

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Cost Considerations

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

Table 2 Engineer's Estimate for Porous Pavement

Porous Pavement													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Grading	SY	$2.00		604	$1,208	1209	$2,418	1812	$3,624	2419	$4,838	3020	$6,040
Paving	SY	$19.00		212	$4,028	424	$8,056	636	$12,084	848	$16,112	1060	$20,140
Excavation	CY	$3.60		201	$724	403	$1,451	604	$2,174	806	$2,902	1008	$3,629
Filter Fabric	SY	$1.15		700	$805	1400	$1,610	2000	$2,300	2800	$3,220	3600	$4,140
Stone Fill	CY	$16.00		201	$3,216	403	$6,448	604	$9,664	806	$12,896	1008	$16,128
Sand	CY	$7.00		100	$700	200	$1,400	300	$2,100	400	$2,800	500	$3,500
Sight Well	EA	$300.00		2	$600	3	$900	4	$1,200	7	$2,100	7	$2,100
Seeding	LF	$0.05		644	$32	1288	$64	1932	$97	2576	$129	3220	$161
Check Dam	CY	$35.00		0	$0	0	$0	0	$0	0	$0	0	$0
Total Construction Costs					**$10,105**		**$19,929**		**$29,619**		**$40,158**		**$49,798**
Construction Costs Amortized for 20 Years					**$505**		**$996**		**$1,481**		**$2,008**		**$2,490**
Annual Maintenance Expense													
Item	Units	Price	Cycles/ Year	Quant. 1 Acre WS	Total	Quant. 2 Acre WS	Total	Quant. 3 Acre WS	Total	Quant. 4 Acre WS	Total	Quant. 5 Acre WS	Total
Sweeping	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Washing	AC	$250.00	6	1	$1,500	2	$3,000	3	$4,500	4	$6,000	5	$7,500
Inspection	MH	$20.00	5	5	$100	5	$100	5	$100	5	$100	5	$100
Deep Clean	AC	$450.00	0.5	1	$225	2	$450	3	$675	3.9	$878	5	$1,125
Total Annual Maintenance Expense					**$3,980**		**$7,792**		**$11,651**		**$15,483**		**$19,370**

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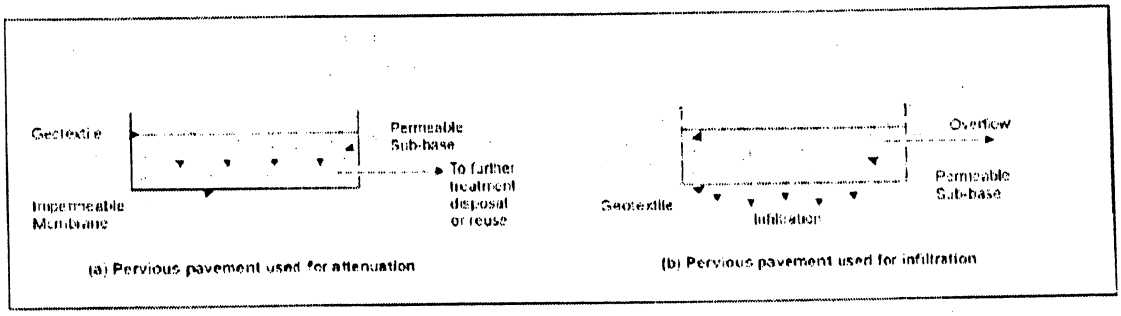


Schematics of a Pervious Pavement System

ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE

TECH SPEC

NUMBER • 9

GUIDE SPECIFICATION FOR THE CONSTRUCTION OF INTERLOCKING CONCRETE PAVEMENT

SECTION 02780
INTERLOCKING CONCRETE PAVERS

Note: This guide specification for concrete paver applications in the U.S. and Canada should be edited to fit project conditions and location. Notes are provided on the use of a compacted aggregate base under the bedding sand and pavers. Other base materials may be used. The user should refer to Interlocking Concrete Pavement Institute ICPI software, *Zaphers™ Details & Specifications for Interlocking Concrete Pavement,* for various guide specifications and detail drawings.

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Concrete paver units. (Concrete paver edge units.)
B. Bedding and joint sand.
C. Edge restraints.

1.02 RELATED SECTIONS

A. Section: [-]-Curbs and Drains.
B. Section: [-]-Aggregate Base.
C. Section: [-]-Cement Treated Base.
D. Section: [-]-Asphalt Treated Base.
E. Section: [-]-Pavements, Asphalt and Concrete.
F. Section: [-]-Roofing Materials.
G. Section: [-]-Bitumen and Neoprene Setting Bed, Acrylic Fortified Mortar Setting Bed.
H. Section: [-]-Geotextiles.

1.03 REFERENCES

Note: Pavements subject to vehicles should be designed in consultation with a qualified civil engineer, in accordance with established flexible pavement design procedures, Pavespec software, and in accordance with the ICPI "Tech Spec" Technical Bulletins.

A. American Society of Testing and Materials (ASTM):

1. C 33, Specification for Concrete Aggregates.
2. C 136, Method for Sieve Analysis for Fine and Coarse Aggregate.
3. C 140, Sampling and Testing Concrete Masonry Units.
4. C 144, Standard Specification for Aggregate for Masonry Mortar.
5. C 936, Specification for Solid Interlocking Concrete Paving Units.
6. C 979, Specification for Pigments for Integrally Colored Concrete.
7. D 698, Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 5.5-lb (2.49 kg) Rammer and 12 in. (305 mm) drop.

8. D 1557, Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 10-lb (4.54 kg) Rammer and 18 in. (457 mm) drop.
9. D 2940, Graded Aggregate Material for Bases or Subbases for Highways or Airports.

B. Canadian Standards Association (CSA):

1. CSA-A231.2-95, Precast Concrete Pavers.
2. CSA-A23.2A, Sieve Analysis of Fine and Coarse Aggregates.
3. CAN/CSA-A23.1-94, Concrete Materials and Methods of Concrete Construction.
4. CAN/CSA-A82.56M-1976, Aggregate for Masonry Mortar.

C. Interlocking Concrete Pavement Institute (ICPI)

1. Tech Spec Technical Bulletins.

1.04 QUALITY ASSURANCE

A. Installation shall be by a contractor and crew with at least one year of experience in placing interlocking concrete pavers on projects of similar nature or dollar cost.
B. Contractor shall hold current Basic Level Certificate from the Interlocking Concrete Pavement Institute contractor certification program.
C. Contractor shall conform to all local, state/provincial licensing and bonding requirements.

1.05 SUBMITTALS

A. Shop or product drawings, and product data.
B. Full size samples of concrete paving units to indicate color and shape selections. Color will be selected by Architect/Engineer/Landscape Architect/Owner from manufacturer's available colors.
C. Sieve analysis for grading of bedding and joint sand.
D. Test results from an independent testing laboratory for compliance of paving unit requirements to [ASTM C 936] [CSA] or other applicable requirements.
E. Manufacturer's certification of conrete pavers by ICPI as having passed applicable ASTM or CSA standards.
F. Indicate layout, pattern, and relationship of paving joints to fixtures and project formed details.

1.06 MOCK-UPS

A. Install a 7 ft x 7 ft (2 m x 2 m) paver area as described in Article 3.02.
B. This area will be used to determine surcharge of the bedding sand layer, joint sizes, lines, laying pattern(s), color(s), and texture of the job.
C. This area shall be the standard from which the work will be judged and shall it be incorporated into the work.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver concrete pavers to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by fork lift or clamp lift. Unload pavers at job site in such a manner that no damage occurs to the product.
B. Cover sand with waterproof covering to prevent exposure to rainfall or removal by wind. Secure the covering in place.
C. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.

1.08 ENVIRONMENTAL CONDITIONS

A. Do not install sand or pavers during heavy rain or snowfall.
B. Do not install sand and pavers over frozen base materials.
C. Do not install frozen sand.

PART 2 PRODUCTS

2.01 CONCRETE PAVERS

Note: Concrete pavers may have spacer bars on each unit. They are recommended for mechanically installed pavers. Manually installed pavers may be installed with or without spacer bars.

A. Supplied by a member of the Interlocking Concrete Pavement Institute (ICPI). The ICPI supplier:
[Name_]
[Address_]
[City_]
[Zip/Postal Code_][State/Province_]
[Phone_]
[Fax_]

B. Product name(s)/shape(s), color(s), overall dimensions, and thickness:
[_in./mm x_in./mm x_in./mm thick.]
[_in./mm x_in./mm x_in./mm thick.]
[_in./mm x_in./mm x_in./mm thick.]

C. Meet the following requirements set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units:

Note: If 3 1/8 in. (80 mm) thick pavers are specified, their compressive strength test results should be adjusted by multiplying them by 1.18 to equate the results to that from 2 3/8 in. (60 mm) thick pavers.

1. Average compressive strength of 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa).
2. Average absorption of 5% with no unit greater than 7% when tested in accordance with ASTM C 140.
3. Resistance to 50 freeze-thaw cycles when tested according to ASTM C 67.

---OR---

C. Meet the following requirements set forth in CSA-A231.2-95, Precast Concrete Pavers:
1. Minimum average cube compressive strength of 7,250 psi (50 MPa).
2. Resistance to 50 freeze-thaw cycles while immersed in a 3% saline solution.

D. Pigment shall conform to ASTM C 979.

2.02 BEDDING AND JOINT SAND

Note: The type of sand used for bedding is often called concrete sand. Sands vary regionally. Screenings and stone dust can be unevenly graded and have material passing the No. 200 (0.075 mm) sieve. Bedding sands with these characteristics should not be used. Contact paver contractors local or manufacturers to the project and confirm sand(s) successfully used in previous similar applications.

A. Clean, non-plastic, free from deleterious or foreign matter, natural or manufactured from crushed rock. Do not use limestone screenings or stone dust that do not conform to the grading requirements in Table 1. When concrete pavers are subject to vehicular traffic, the sands shall be as hard as practically available.

Note: If the hardness of the bedding sand is not sufficient or questionable for the application (usually a heavily trafficked thoroughfare), contact the ICPI for information and specifications on assessing bedding sand durability under heavy traffic loads.

B. Sieve according to [ASTM C 136] [CSA-A23.2A].
C. Conform to the grading requirements of as shown in Table 1.

Note: Use ASTM or CSA standards as applicable.

Table 1

Grading Requirements for Bedding Sand

ASTM C 33		CSA A23.1-M94	
Sieve Size	**Percent Passing**	**Sieve Size**	**Percent Passing**
3/8 in.(9.5 mm)	100	10 mm	100
No. 4 (4.75 mm)	95 to 100	5 mm	95 to 100
No. 8 (2.36 mm)	85 to 100	2.5 mm	80 to 100
No. 16 (1.18 mm)	50 to 85	1.25 mm	50 to 90
No. 30 (0.600 mm)	25 to 60	0.630 mm	25 to 65
No. 50 (0.300 mm)	10 to 30	0.315 mm	10 to 35
No. 100 (0.150 mm)	2 to 10	0.160 mm	2 to 10

Note: Bedding sand may be used for joint sand. However, extra effort in sweeping and compacting the pavers may be required in order to completely fill the joints. If joint sand other than bedding sand is used, the gradations shown in Table 2 are recommended. Joint sand should never be used for bedding sand.

D. The joint sand shall conform to the grading requirements as shown in Table 2 below:

Note: Use ASTM or CSA standards as applicable.

Table 2

Grading Requirements for Joint Sand

	ASTM C 144 Natural Sand	ASTM C 144 Manufactured Sand	CSA A82.56M	
Sieve Size	**Percent Passing**	**Percent Passing**	**Sieve Size**	**Percent Passing**
No. 4 (4.75 mm)	100	100	5 mm	100
No. 8 (2.36 mm)	95 to 100	95 to 100	2.5 mm	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100	1.25 mm	90 to 100
No. 30 (0.600 mm)	40 to 75	40 to 100	0.600 mm	35 to 80
No. 50 (0.300 mm)	10 to 35	20 to 40	0.300 mm	15 to 50
No. 100 (0.150 mm)	2 to 15	10 to 25	0.150 mm	2 to 15
No. 200 (0.075 mm)	0	0 to 10		

2.03 EDGE RESTRAINTS

Note: See ICPI Tech Spec 3, "Edge Restraints for Interlocking Concrete Pavements," for guidance selecting on edge restraints for various applications.

A. Edge restraints shall be [timber][plastic][concrete][aluminum][steel][pre-cast concrete][cut stone][concrete] [as manufactured by] [and shall conform to the following standards:]

PART 3 EXECUTION

3.01 EXAMINATION

Note: For installation on a compacted aggregate base and soil subgrade, the specifier should be aware that the top surface of the pavers may be 1/8 to 1/4 in. (3 to 6 mm) above the final elevations after compaction. This difference in initial and final elevation is to compensate for possible minor settling.

A. Verify that subgrade preparation, compacted density and elevations conform to the specifications.

Note: Compaction of the soil subgrade is recommended to at least 95% standard Proctor density per ASTM D 698 for pedestrian areas and residential driveways. Compaction to at least 95% modified Proctor density per ASTM D 1557 is recommended for areas subject to heavy vehicular traffic. Stabilization of the subgrade and/or base material may be necessary with weak or saturated subgrade soils. The Architect/Engineer should inspect subgrade preparation, elevations, and conduct density tests for conformance to specifications.

B. Verify that geotextiles, if applicable, have been placed according to specifications and drawings.
C. Verify that aggregate base materials, thickness, compaction, surface tolerances, and elevations conform to the specifications.

Note: Local aggregate base materials typical to those used for highway flexible pavements are recommended, or those conforming to ASTM D 2940. Compaction is recommended to not less than 95% Proctor density in accordance with ASTM D 698 is recommended for pedestrian areas and residential driveways. Compaction is recommended to not less than 98% modified Proctor density according to ASTM D 1557 is recommended for vehicular areas.

Note: The aggregate base should be spread and compacted in uniform layers not exceeding 6 in. (150 mm) thickness. Recommended base surface tolerance should be plus or minus 3/8 in. (10 mm) over a 10 ft. (3 m) straight edge. The Architect/Engineer should inspect geotextile materials and placement (if applicable), base preparation, surface tolerances, elevations, and conduct density tests for conformance to specifications. See ICPI Tech Spec 2, "Construction of Interlocking Concrete Pavements" for further guidance on construction practices.

Note: Mechanical tampers are recommended for compaction of soil subgrade and aggregate base around lamp standards, utility structures, building edges, curbs, tree wells and other protrusions. In areas not accessible to large compaction equipment, compact to specified density with mechanical tampers.

D. Verify location, type, installation and elevations of edge restraints around the perimeter area to be paved.

---OR---

D. Install edge restraints per the drawings [and manufacturer's recommendations][at the indicated elevations].
E. Verify that base is dry, uniform, even, and ready to support sand, pavers, and imposed loads.
F. Beginning of bedding sand and paver installation means acceptance of base and edge restraints.

3.02 INSTALLATION

A. Spread the bedding sand evenly over the base course and screed to a nominal 1 in. (25 mm) thickness, not exceeding 1 1/2 in. (40 mm) thickness. The screeded sand should not be disturbed. Place sufficient sand to stay ahead of the laid pavers. Do not use the bedding sand to fill depressions in the base surface.
B. Ensure that pavers are free of foreign material before installation.
C. Lay the pavers in the pattern(s) as shown on the drawings. Maintain straight pattern lines.
D. Joints between the pavers on average shall be between 1/16 in. and 3/16 in. (2 mm to 5 mm) wide.

Note: Some paver shapes require a larger joint. Consult manufacturer for recommended joint widths.

E. Fill gaps at the edges of the paved area with cut pavers or edge units.

Note: Units cut no smaller than one-third of a whole paver are recommended along edges subject to vehicular traffic.

F. Cut pavers to be placed along the edge with a [double blade paver splitter or] masonry saw.
G. Use a low amplitude plate compactor capable of at least 5,000 lbf (22 kN) compaction at a frequency of 75 hz –100 hz.
H. Compact the pavers, sweeping dry joint sand into the joints and vibrating until they are full. This will require at least two or three passes with the compactor. Do not compact within 3 ft (1 m) of the unrestrained edges of the paving units.
I. All work to within 3 ft (1 m) of the laying face must be left fully compacted with sand-filled joints at the end of each day. Cover the laying face with plastic sheets overnight if not closed with cut and compacted pavers.
J. Sweep off excess sand when the job is complete.
K. The final surface elevations shall not deviate more than 3/8 in. (10 mm) under a 10 ft (3 m) long straightedge.
L. The surface elevation of pavers shall be 1/8 to 1/4 in. (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.

3.03 FIELD QUALITY CONTROL

A. After removal of excess sand, check final elevations for conformance to the drawings.

Interlocking Concrete Pavement Institute
1444 Eye Street NW, Suite 700
Washington, DC 20005-2210
Phone: (202) 712-9036
(800) 241-3652
Fax: (202) 408-0285
E-Mail: ICPI@bostromdc.com
Web site: http://www.icpi.org

Canada:
PO Box 23053
55 Ontario Street
Milton, ON L9T 2M0

ATTACHMENT F
OPERATION AND MAINTENANCE PROGRAM
FOR TREATMENT BMP

(**NOTE:** INFORMATION REGARDING OPERATION AND MAINTENANCE CAN BE OBTAINED FROM THE FOLLOWING WEB SITE:

http://www.sdcounty.ca.gov/dpw/watersheds/land_dev/susmp.html

Estimated O & M Costs for BMP

Estimated values derived from Caltrans Pilot BMP Study. This spreadsheet will change as additional data becomes available.

BIOFILTER - SWALES

Preventive Maintenance and Routine Inspections

ROUTINE ACTIONS	MAINTENANCE INDICATOR	FIELD MEASUREMENT	MEASUREMENT FREQUENCY	MAINTENANCE ACTIVITY	SITE-SPECIFIC FREQUIREMENTS	Labor Hrs	Labor Rate	Labor Cost	Equipment Type	Equipment Days	Equipment Rate	Equipment Cost	Materials Item	Materials Cost	Total Cost	Comments
Height of vegetation	Average vegetation height exceeds 12 inches emergence of trees. or woody vegetaton	Visual inspection of vegetation throughout strip/swale	Once during wet season, once during dry season, (depending on growth)	Cut vegetation to an average height of 6 inches	Remove any trees, or woody vegetation	10	44	436	one ton truck & hydroseeder	2	26.84	54	string trimmer, rake, fork, bags, safety equipment	50	540	
Assess adequate vegetative cover	Less than 90 percent coverage in strip invert/swale or less than 70 percent on swale side slope	Visual inspection of strip/swale. Prepare a site schematic to record location and distribution of baren or browning spots to be restored. File the schematic for assessment of persistent problems.	Assess quantity needed in May each year late wet season and late dry season.	Reseed/revegetate barren spots by Nov.		8	44	349	one-ton truck & hydroseeder	1	48.15	48	seed	150	547	
				Scarify area to be restored, to a depth of 2-inches. Restore side slope coverage with hydroseed mixture.		0	44	0	one-ton truck & hydroseeder	0	27	0			0	
				If after 2 applications (2 seasons) of reseeding/revegetating and growth is unsuccessful both times, an erosion blanket or equivalent protection will be installed over eroding areas		0	44	0	one-ton truck & hydroseeder	0	27	0	blanket	0	0	
Inspect for debris accumulation	Debris or litter present	visual observation	During routine trashing per Districts schedule	Remove litter and debris	None	0	0	0	one ton truck & hydroseeder							
	Sediment at or near vegetation height, channeling of flow,			Remove sediment. If flow is channeled, determine cause and take corrective action. If sediment becomes deep enough to change the flow gradient, remove sediment during dry season, characterize and properly dispose of					one-ton				seed, testing and			

Inspect for accumulated sediment	inhibited flow due to change in slope.	Visual observation	Annually	sediment, and revegetate. Notify engineer to determine if regrading is necessary. If necessary, regrade to design specification and revegetate swale/strip. If regrading is necessary, the process should start in May. Revegetate strip/swale in Nov. Target completion prior to wet season.	None	16 2	44 44	698 57	truck & hydroseeder	1	48	48 0	disposal of sediment	300	1046 87	once every three years
Inspect for burrows	Burrows, holes, mounds	Visual observation	Annually and after vegetation trimming	Where burrows cause seepage, erosion and leakage, backfill firmly.		0	0	0	one-ton truck & hydroseeder	0	27	0			0	
General Maintenance Inspection	Inlet structures, outlet structures, side slopes or other features damaged, significant erosion, emergence of trees, woody vegetation fence damage, etc.	Visual observation	Semi-Annually, late wet season, And late dry season.	Corrective action prior to wet season. Consult engineer if an immediate solution is not evident.	Remove any trees, or woody vegetation.	16	44	698	one-ton truck & hydroseeder	2	27	54			752	
TOTAL BIO FILTER SWALES						52		2269				203.66		500	2972	

TOTAL YEARLY BMP COST $2,972

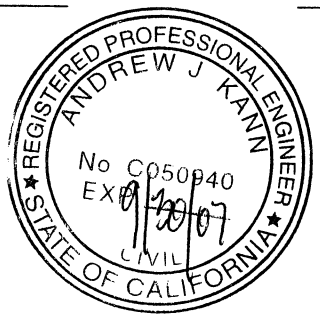
ATTACHMENT G

CERTIFICATION SHEET

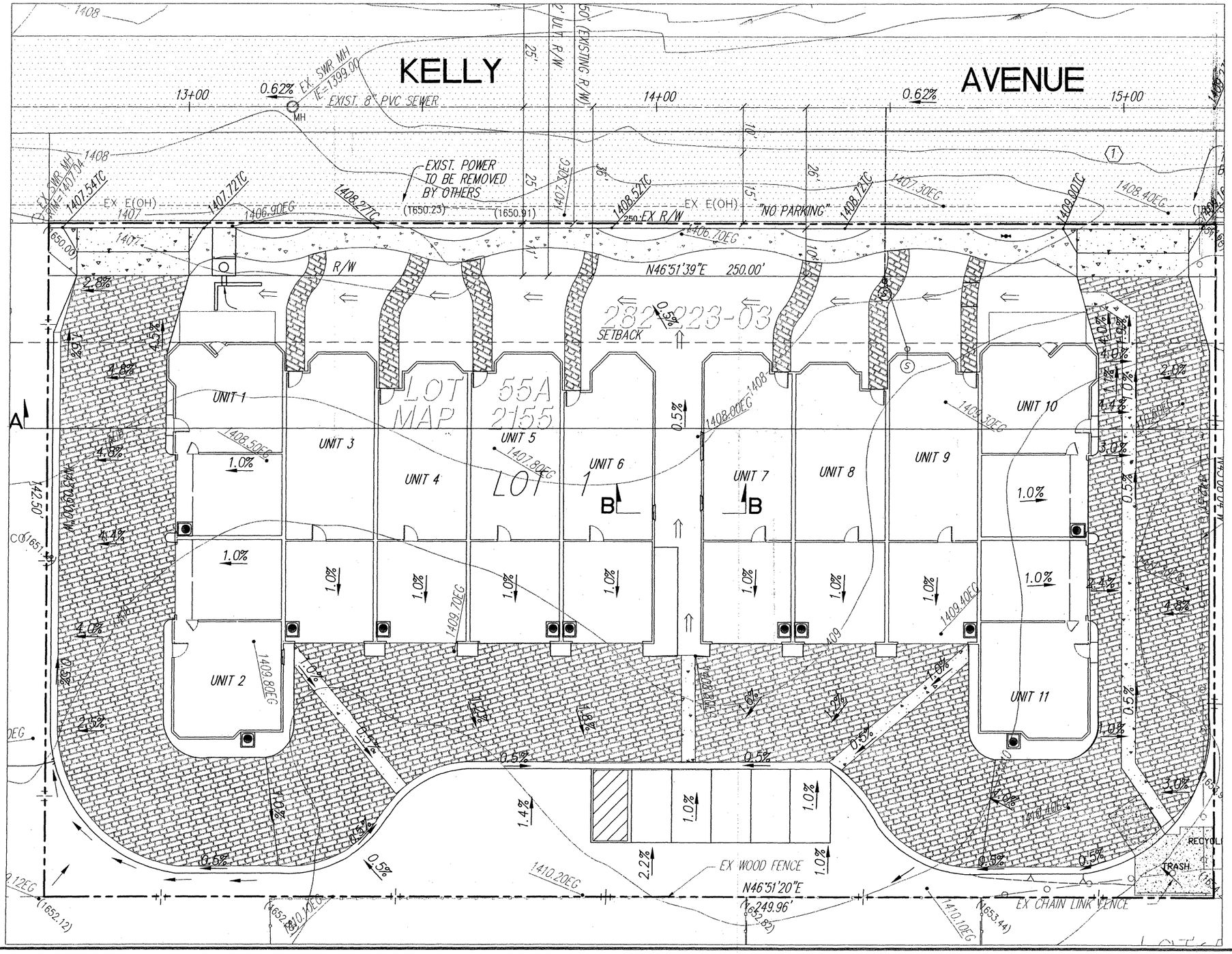
This Stormwater Management Plan has been prepared under the direction of the following Registered Civil Engineer attests to the technical information contained herein and the engineering data upon which recommendations, conclusions, and decisions are based.

Andrew J. Kann
Registered Civil Engineer

9-7-07
Date



PROJECT MAP
SUNRISE VILLAS, KELLY AVENUE



PARTNERS
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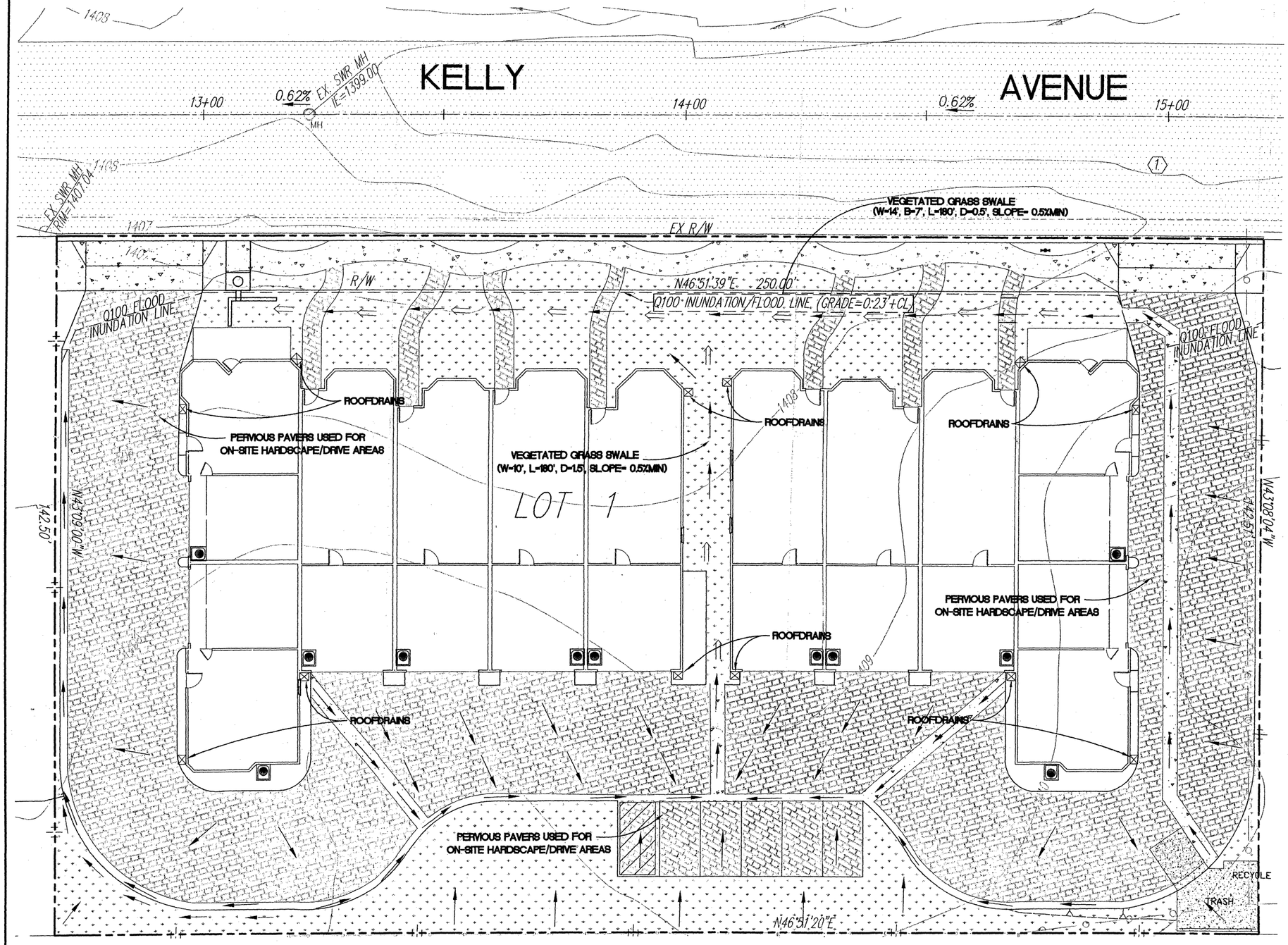
San Diego, CA. 92127
Ph. (858) 376-3444
Fax: (858) 376-3555

POST-CONSTRUCTION BMPs
SUNRISE VILLAS, KELLY AVENUE



LEGEND:

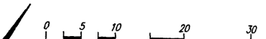
PROPOSED ROOF DRAIN ⊠

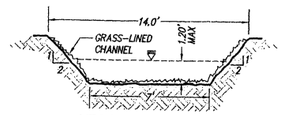
PROPOSED DIRECTION OF FLOW

PROPOSED GRASS-LINED SWALE ⇒

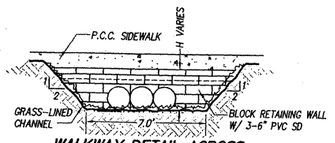
INTERLOCKING MODULAR PAVERS (PERVIOUS HARDSCAPE/DRIVABLE SURFACE)

LANSCAPED/BIOFILTRATION AREA.

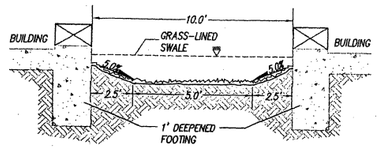




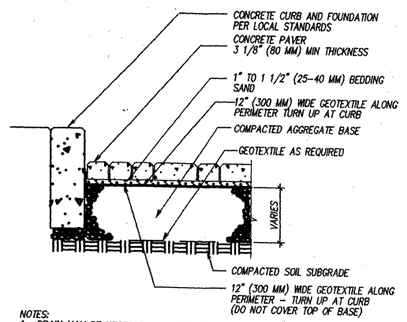
VEGETATED GRASS SWALE DETAIL
NO SCALE



WALKWAY DETAIL ACROSS SWALE ALONG FRONTAGE
NO SCALE



GRASS SWALE DETAIL BETWEEN BUILDINGS
NO SCALE



NOTES:
1. DRAIN MAY BE NECESSARY IN SLOW DRAINING SUBGRADE.
2. BASE THICKNESS VARIES WITH TRAFFIC, CLIMATE, AND SUBGRADE CONDITIONS. COLDER CLIMATES AND WEAK SOILS MAY REQUIRE THICKER BASES. CONSULT ICPI TECH SPEC 4 TO DETERMINE BASE THICKNESS.
3. CONSULT ICPI TECH SPEC 2 AND CSI MANU SPEC FOR GUIDELINES AND SPECIFICATIONS FOR BASE MATERIALS, SUBGRADE SOIL AND BASE COMPACTION.
4. DO NOT COVER ENTIRE TOP OF AGGREGATE BASE WITH GEOTEXTILE.

PERVIOUS PAVER DETAIL FOR STREET/PARKING AREAS WITH COMPACTED AGGREGATE BASE

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611PCBMP.dwg 4-12-07 9:57:42 am EST

OFF-SITE POST-CONSTRUCTION BMPs
SUNRISE VILLAS, KELLY AVENUE

LEGEND:

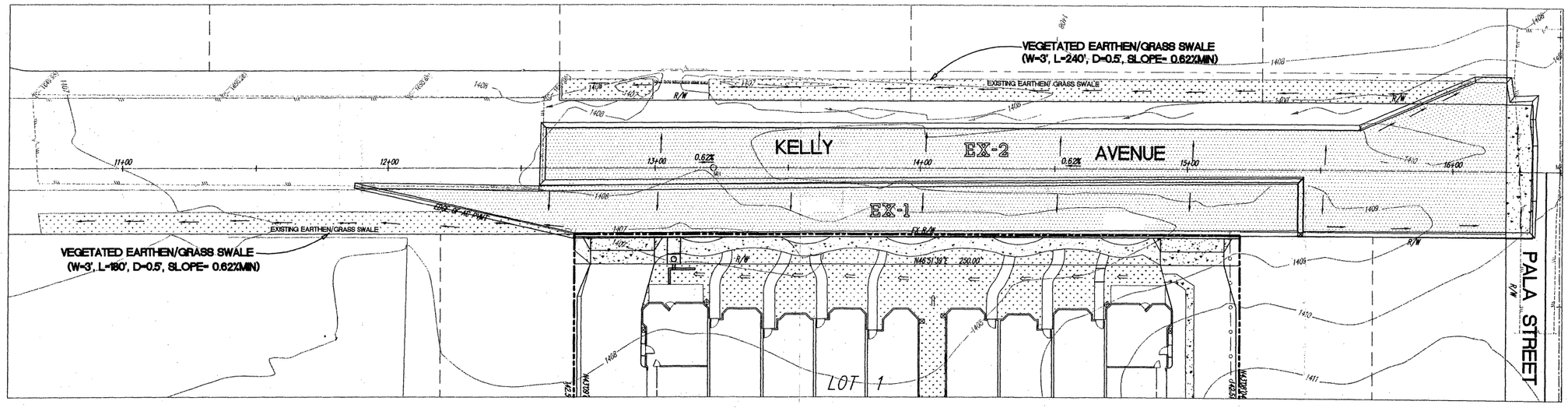
PROPOSED DIRECTION OF FLOW .....

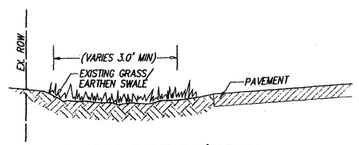
BIOFILTRATION AREA .....

SCALE: 1"=20'

0 10 20 40 60

GRAPHICAL SCALE





EXISTING EARTHEN/ GRASS SWALE DETAIL

NO SCALE

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